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A NEW ACTINOPTERYGIAN FISH (PALEONISCIFORMES) FROM THE UPPER MISSISSIPPIAN BLUESTONE FORMATION OF WEST VIRGINIA

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Abstract.—A new genus and species of deep-bodied paleonisciform fish, *Tanypterichthys pridensis,* is described from near the base of the Pride Shale Member of the Bluestone Formation of the Upper Mississippian Series (Namurian A equivalent) in West Virginia. Its unusually large size (roughly 0.5 m), diamond-shaped deep body, very large pectoral fins, and the details of its scale ornamentation demonstrate that this is a new and unique paleonisciform. The type specimen of *Tanypterichthys,* found immediately above a basal rubble zone representing a marine transgressive event, is associated both with goniatitic cephalopods and with plant and tree fragments. This association indicates that it was entombed in a shallow coastal marine or marginal marine deltaic depositional environment. The functional morphology of *Tanypterichthys* and its burial environment suggest that this fish may have inhabited quiet waters along the coastal reaches of rivers and brackish estuaries, where kelplike colonial algae or canelike aquatic plants grew in dense stands.

A large fossil fish, missing most of the skull and the caudal and dorsal fins, was discovered in an ellipsoidal carbonate concretion in a roadcut near Princeton, West Virginia (Fig. 1), by John Windolph during geologic investigations in the U.S. Geological Survey Upper Mississippian/Pennsylvanian stratotype project (Englund et al. 1979). The concretion is one of many, mostly unfossiliferous, in a discrete zone near the base of the Pride Shale Member of the Bluestone Formation (Upper Mississippian Series) (Fig. 2).

The fish was discovered by splitting the concretion, whereupon an internal view of the scale pattern and left posterior skull elements (Fig. 3) was revealed. Much of the scale pattern and the conformation of the anal fin was discernible from this internal view, but nothing could be ascertained about the pelvic fins and little about the pectoral fins or the external ornamentation of the scales. For this reason, we decided that the left side of the fish should be acid prepared to try to determine something about its external appearance. The exposed parts of the left side first were photographed by Deborah Dwornik of the U.S. Geological Survey, then the left half of the fish was taken to the National Museum of Natural History where Arnold Lewis and Daniel Chaney impregnated the exposed part of the left side of the fish in plastic. After the plastic polymerized, they removed all but a 1-inch slab of the concretion with a diamond saw. The authors then immersed the block in a formic acid bath to remove most of the external concretionary covering. Unfortunately, some layers were rich in pyrite and were nearly unaffected by the formic acid. In those areas, material could not be removed without dislodging fragments of scales. This caused a certain amount of breakage to the specimen, but most of the outer nodular coating was successfully removed by the acid treatment to reveal a complex papillate to stoutly ridged pattern on the scales and the outlines of the pectoral and pelvic fins (Fig.

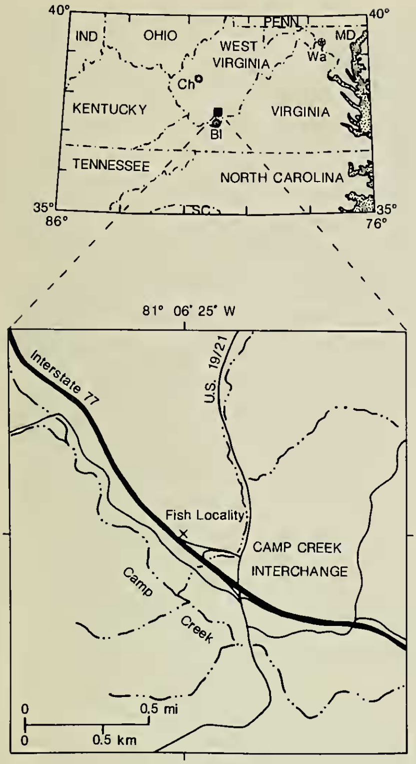

Fig. 1. Map showing the locality in West Virginia (marked by X) of the type specimen of *Tanypterichthys pridensis.* Bl = Bluefield, W. Va.; Ch = Charleston, W. Va.; Wa = Washington, D.C.

4). The right half of the fish remains in its original concretionary coat.

The pectoral fin, pelvic fin, most of the anal fin, posterior skull margin, and central body region are present and well preserved, but the caudal fin, dorsal fin, upper body outline, and much of the skull are missing. The nearly perfect articulation of the fossil fish suggests that the entire animal probably was once in the rock, but that the parts of the skeleton not enclosed by the concretion were destroyed by weathering and erosion.

Geologic Setting

Tanypterichthys was discovered in a large ellipsoidal limestone concretion collected from a zone of concretions that lies approximately 6 inches above the base of the

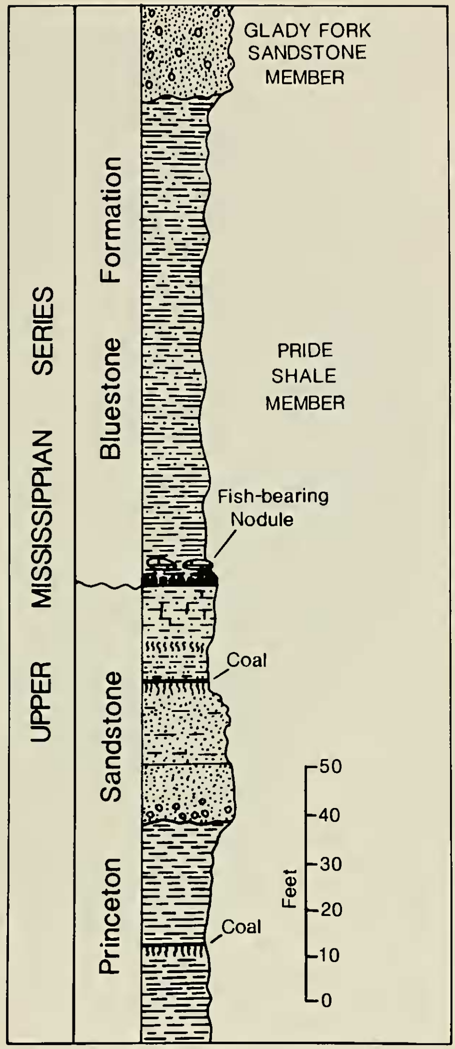

Fig. 2. Detailed stratigraphic column of the upper Princeton Sandstone and lower Bluestone Formation at the discovery locality for *Tanypterichthys pridensis.* The fish-bearing concretion zone occurs near the base of the Pride Shale Member of the Bluestone Formation. The unconformably underlying Princeton Sandstone and the conformably overlying Glady Fork Sandstone Member of the Bluestone Formation were formed in deltaic environments, as shown by the presence of coal and root casts, but at least the basal Pride Shale Member formed in a marginal-marine environment of deposition as shown by the successive presence of cone-shaped nautiloid and coiled goniatitic cephalopod shells in the 6-inch interval below the fish-bearing nodule zone, and the presence of inarticulate brachiopods and wood fragments within the fish-bearing nodule zone.

Fig. 3. Internal view of the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949) before it was mounted in plastic and exhumed from the matrix on the other side with formic acid. These and the following photographs were taken by Deborah Dwornik (U.S. Geological Survey, Reston).

Pride Shale Member (Fig. 2). The Pride Shale Member is the basal member of the Bluestone Formation (Upper Mississippian Series) and is correlative with late Chesterian age rocks of the midcontinent and with Namurian A strata of western and central Europe.

The Princeton Sandstone immediately underlies the Pride Shale Member and is approximately 60 feet thick at the fossil site. Outcrops of the Princeton extend for more than 100 miles along the southeastern edge of the Appalachian Basin, forming a belt of clastic wedges and deltaic sequences that thin to the northwest. The Princeton Sandstone, which resulted from erosion after a widespread tectonic event, consists of lenses of medium-light-gray to medium-gray polymictic conglomerate, coarse- to fine-grained conglomeratic subgraywacke, sandstone, siltstone, shale, underclay, and coal. Basal conglomerate and sandstone beds grade coarse to fine upward, are massive to thin-bedded, and form impressive bluffs to the southeast along the Bluestone River. The clasts are diverse in size and source, consisting of well-rounded to angular fragments of quartz sandstone, siltstone, shale, lime-

Fig. 4. External view of the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949) after being treated with formic acid.

stone, ironstone, chert, and coalified plant and tree-trunk fragments. Many of the lithic fragments were derived from limestone and clastic sediments immediately underlying the Princeton, but others came from more distant sources of older Paleozoic sedimentary and Proterozoic to Paleozoic metamorphic and igneous rocks that occur to the southeast. Sandstone beds, located at distal parts of clastic wedges and locally at the upper part of deltaic sequences, are light-gray, moderately quartzose, and lenticular. This description suggests the formation of beach and barrier-bar deposits by winnowing and reworking of sediments through high-energy coastal and long-shore processes. The Princeton Sandstone locally includes thin-bedded to nonbedded medium-gray to greenish-gray siltstone, shale, limestone concretions, coal, and underclay. The several rooted underclays, overlain by thin coalbeds no more than 2 inches thick, indicate periods of protected and stable swamp-forming conditions. Thin roof shales above the coal beds contain partially abraded plant fossils (identified by W. H. Gillespie in Englund et al. 1985) including *Sphenophyllum tenerrimum, Stigmaria stellata,* *Pecopteris aspera, Archaeocalamites* sp., and *Sphenopteris elegans.* These floral elements are characteristic of the Upper Mississippian of North America and the Namurian A of western and central Europe. They occur in zone 3A, above the Upper Mississippian *Fryopsis* zone (zone 3 of Read and Mamay 1964) and below the *Neuropteris pocahontas* zone (zone 4 of Read and Mamay 1964), which marks the base of the Pennsylvanian System.

Locally, the Princeton Sandstone is overlain by an irregularly bedded rubble zone that ranges from an inch to more than a foot in thickness. It consists of a polymictic conglomerate in a silty sandstone matrix and includes well rounded quartz pebbles and other diverse lithic fragments as much as 1 inch in diameter. This rubble zone forms an extensive resistant ledge at the base of the Pride Shale Member, and it has been traced for more than 5 miles to the southeast of the locality where the type specimen of *Tanypterichthys* was found. This zone marks a disconformable contact that was formed by a widespread marine-transgressive event at the beginning of Bluestone deposition.

The Pride Shale Member is the basal unit of the Bluestone Formation and is approximately 100 feet thick at this locality. It is dark-gray, very fissile, carbonaceous, and silty. In places, it is bioturbated and includes thin, silty lenticular beds and flaser bedding. A few thin grayish-red units are present at the base, beneath the more widespread zone of sparsely fossiliferous limestone concretions in which the fossil fish was found. Exposed in roadcuts northwest of the fossil site are several large slump, scower, and channel features that are overlain and underlain by horizontal bedding. These unrooted features suggest the action of strong tidal influences and submarine currents. Associated with these beds are marine and brackish invertebrate fossil assemblages, which were collected by T. W. Henry of the U.S. Geological Survey and which are consistent with a shallow bayfill or lagoonal depositional environment for the Pride Shale Member. Above the Pride, coarse clastic rocks characterize the succeeding Glady Fork Sandstone Member of the Bluestone Formation. These clastic rocks are similar to those previously described from the underlying Princeton Formation.

Taxonomic Description

The fish described here (see Figs. 5, 6, 7, 8) would seem to be readily assigned to the Paleonisciformes in view of the persistent development of branchiostegal rays in its cheek region and the unreduced number of rays in its fins. The order Paleonisciformes traditionally has been divided into two suborders (Moy-Thomas 1971), one (Paleoniscoidei) for normally shaped, fusiform types and the other (Platysomoidei) for deep-bodied forms reminiscent of our fish. Up to four families (Amphicentridae, Platysomidae, Bobasatranidae, and Dorypteridae) have been recognized, though variations on this theme have been proposed. The Amphicentridae and Platysomidae were combined into a single family by Berg et al. (1964). Fowler (1958) suggested that the term Uropterygidae should be favored over the term Platysomidae because the latter name is pre-empted, but this practice has not been followed by any subsequent worker. Berg (1940b) suggested placing the Bobasatranidae into a separate order, the Bobasatraniformes. This practice generally has been followed.

In recent years, this relatively simple taxonomy has collapsed. Campbell and Phuoc (1983) have pointed out that the skull of the type species of *Platysomus,* the Permian *P. gibbosus,* shows derived characteristics which indicate that it, and by definition the genus *Platysomus,* belong in the Bobasatraniformes. But it is unlikely that Mississippian and Pennsylvanian species which have been classified in *Platysomus* (or any of the other genera formerly classified in the Platysomidae and Platysomoidei) share these derived traits. Therefore, although

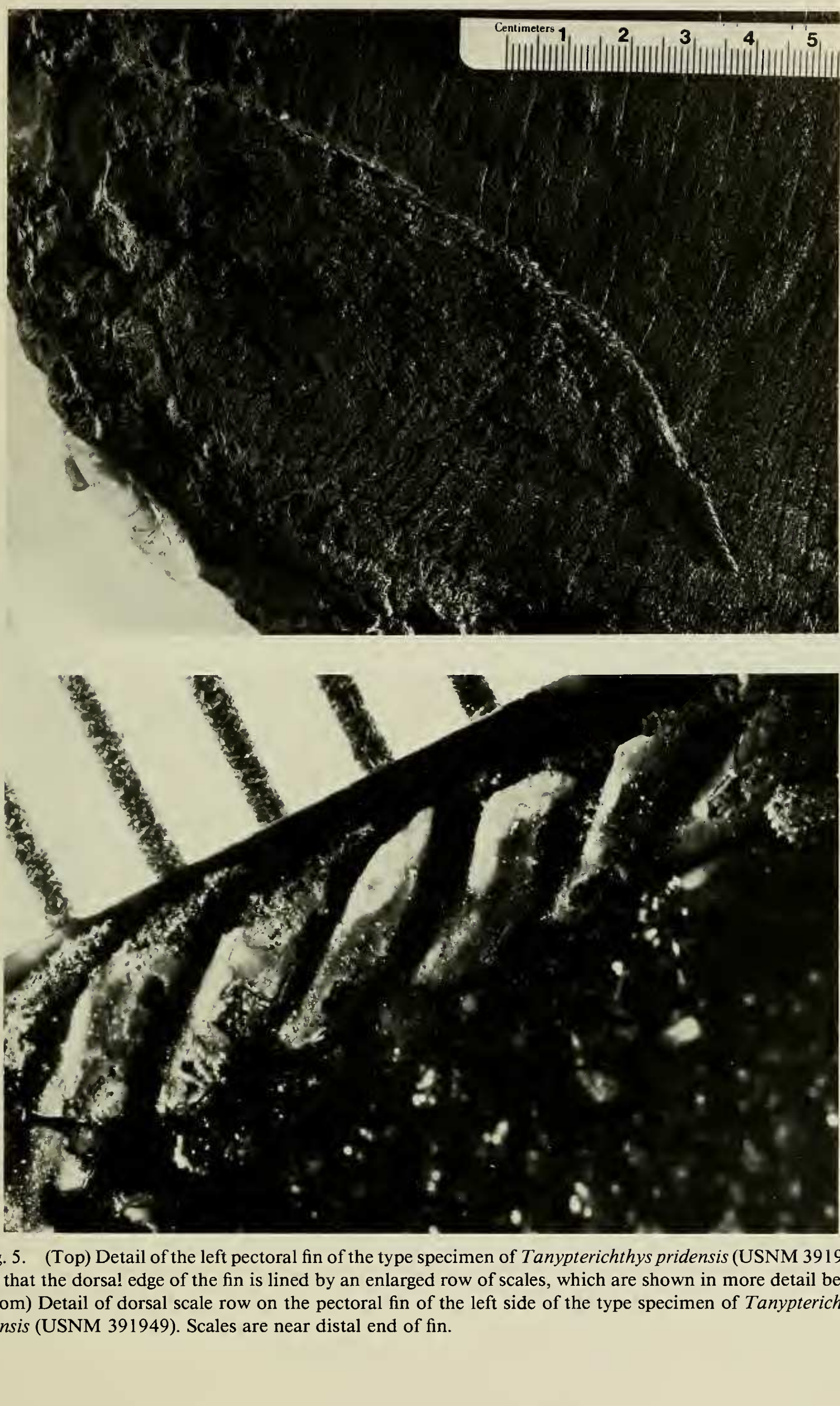

Fig. 5. (Top) Detail of the left pectoral fin of the type specimen of *Tanypterichthys pridensis* (USNM 391949). Note that the dorsal edge of the fin is lined by an enlarged row of scales, which are shown in more detail below. (Bottom) Detail of dorsal scale row on the pectoral fin of the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949). Scales are near distal end of fin.

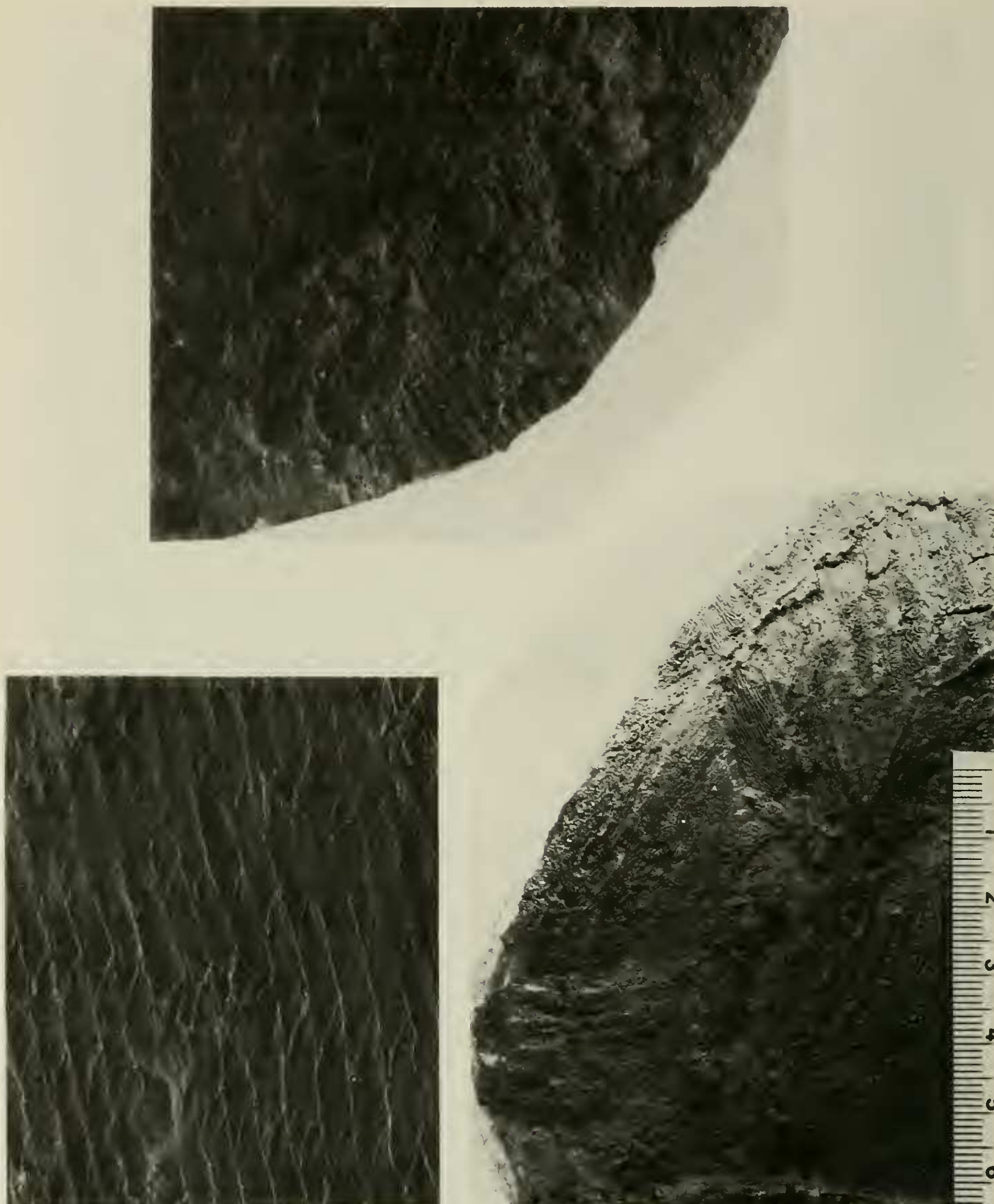

Fig. 6. (Top) Detail of anterior scale pattern on the anal fin of the type specimen of *Tanypterichthys pridensis* (USNM 391949), seen in internal view on the left side before acid preparation. (Lower left) Detail of internal flank scale pattern on the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949) before acid preparation. (Lower right) Detail of the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949) showing the vermiform sculpture on the posterior cranial elements, and the pustulose pattern on the anterior flank scales.

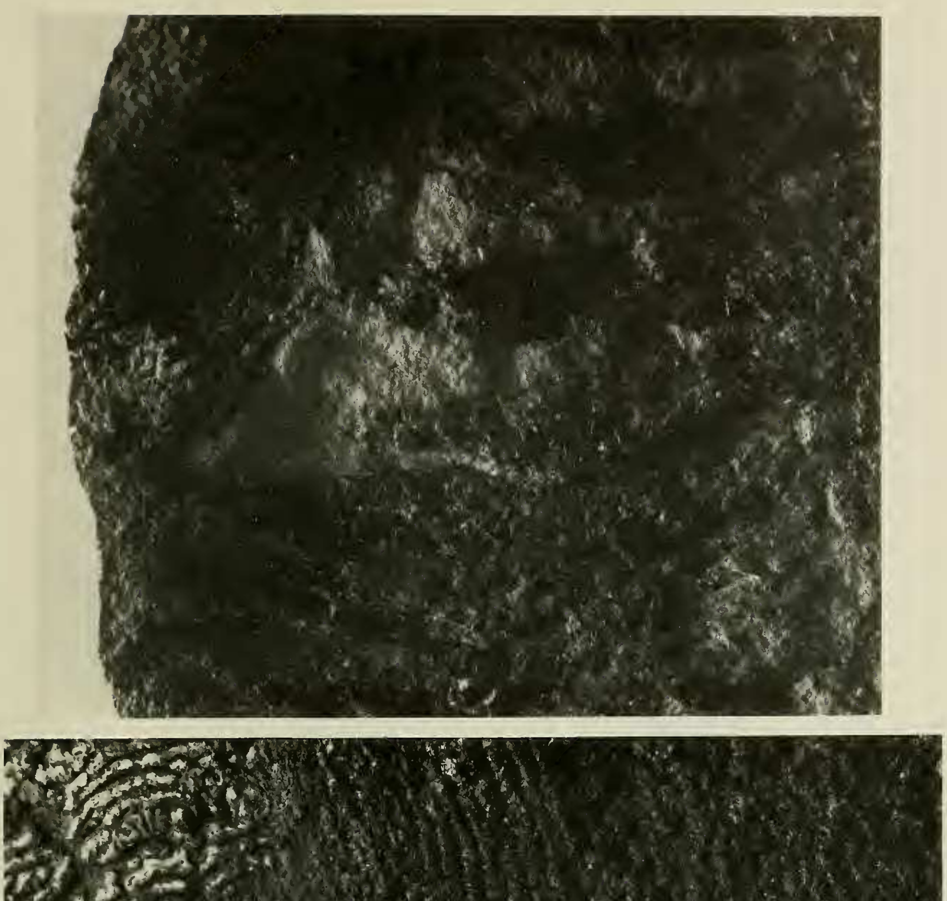

Fig. 7. (Top) Detail of internal ventral skull element pattern on the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949) before acid preparation. (Bottom) Detail of lower anterior flank region of the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949), showing the ventral pectoral fin rays (upper right diagonal) and the ridgelike texture on the ventral flank scales beneath the pectoral fin (lower left diagonal).

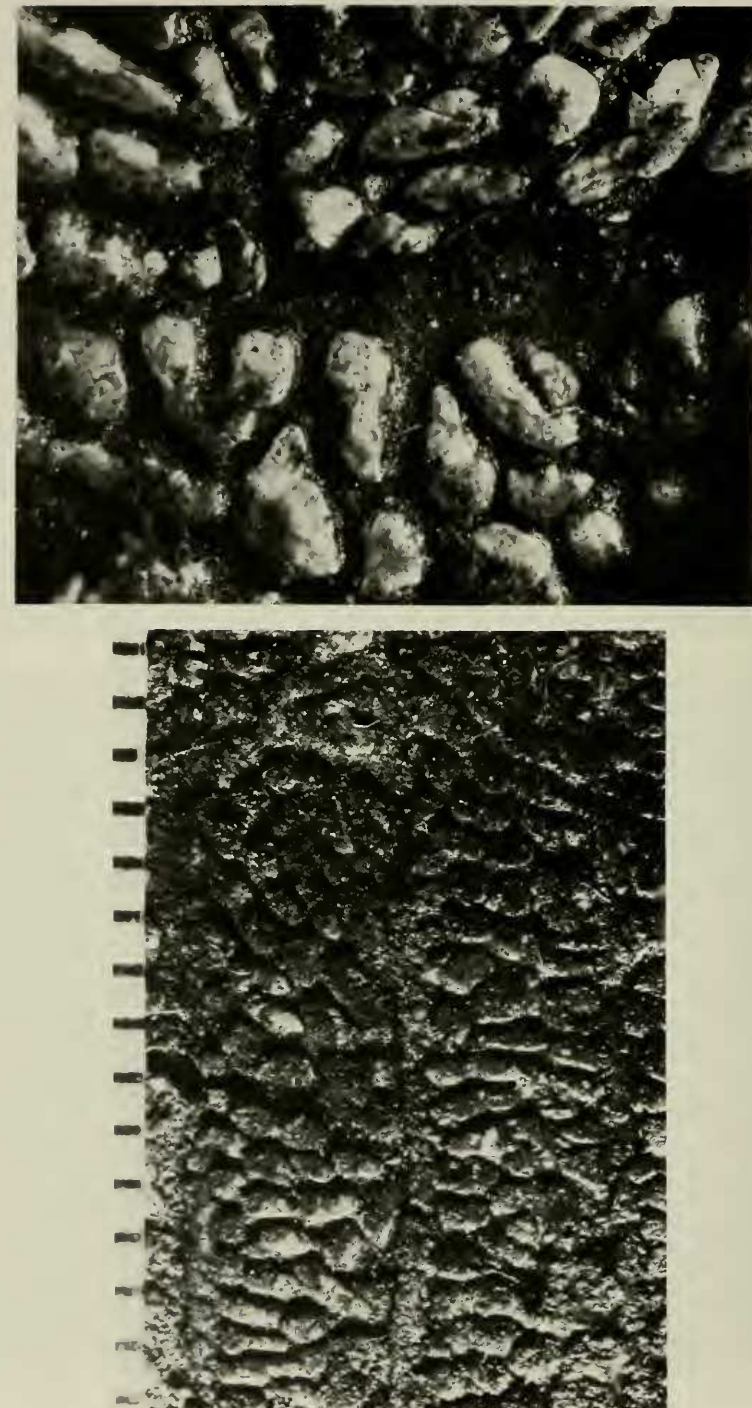

Fig. 8. (Top) Detail of the ornamentation pattern on a single antero-medial flank scale from the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949). (Bottom) Detail of papillate ornamentation on a single postero-medial flank scale from the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949).

these older forms can be properly retained within the Paleonisciformes, the type genus for the family Platysomidae and suborder Platysomoidei now is removed so that the taxonomy of the remaining deep-bodied paleonisciforms is near chaos. It is beyond the scope of this paper to sort through the various phylogenetic pathways in this complex of genera and to classify them correctly, so for now our new form is simply placed in Paleonisciformes without familial assignment. Future work could even demonstrate that it deserves its own familial assignment.

Because a meaningful classification for deep-bodied paleonisciform fishes has not been worked out, the genera which have been described from rocks of Early Mississippian to Middle Triassic age simply are considered in seriatim. These are *Mesolepis, Paramesolepis, Platysomus* (in part), *Schaefferichthys, Soetendalichthys, Wardichthys, Cheirodopsis, Cheirodus* (=*Amphicentrum*), *Eurynotus, Paraeurynotus, Proteurynotus, Adroichthys, Globulodus* (=*Lekanichthys*), *Eurynotoides,* and *Caruichthys.*

Most of these fish are extremely deep bodied and narrow, but *Mesolepis* (Young 1866, Traquair 1879, Ward 1890, Traquair 1907, Pruvost 1919, Van der Heide 1943) and *Eurynotus* (Agassiz 1833–43, Koninck 1878, Traquair 1879) evolved into only slightly deep-bodied forms and even *Proteurynotus* (Moy-Thomas and Dyne 1938) is not nearly so deep bodied as *Tanypterichthys. Adroichthys* (Gardiner 1969), *Paramesolepis* (Traquair 1881, Moy-Thomas and Dyne 1938), *Cheirodopsis* (Traquair 1881, Moy-Thomas and Dyne 1938), and *Wardichthys* (Traquair 1874, 1879, 1907) all have a short-based and posteriorly located anal fin; this contrasts sharply with the elongate, anteroventrally expanded anal fin in *Tanypterichthys.*

Soetendalichthys (Gardiner 1969) is somewhat similar to *Tanypterichthys* in body shape and possibly in anal fin elongation, but it contrasts with our form in that its flank scales are not nearly so vertically elongated. Additionally, it has a much more tubercular scale ornamentation, and the pin and socket connections between scales in each column are at the center of each scale rather than along the front or back margin.

Cheirodus (Newberry and Worthen 1870; Hancock and Atthey 1872; Traquair 1879; Ward 1890; Pruvost 1919, 1930; White 1937; Dyne 1939; Van der Heide 1943; Bardack 1979) is markedly distinct from *Tanypterichthys* in its small size (5–15 cm), tubercular scale ornamentation, the extreme constriction between the tail and body, and the presence in at least some forms of body "horns" drawn up before the dorsal and anal fins like keels.

Platysomus has been used as a generic name for more species of deep-bodied paleonisciforms than any other (Agassiz 1833–43; Eichwald 1857; Hancock and Atthey 1872; Ward 1890; Cope 1891; Pruvost 1930; Moy-Thomas and Dyne 1938; Van der Heide 1943; Wilson 1950; Zidek 1972; Simpson 1979; Schaumberg 1976, 1980). As noted above, the type species of *Platysomus* now is considered to be bobasatraniform, so at least part of the Permian species assigned to that genus belong in that order. Mississippian and Pennsylvanian species assigned to *Platysomus* are grossly similar to *Tanypterichthys,* but they differ consistently from our fish in their possession of a finely vermiform scale-ornamentation pattern (aligned in parallel vertical rows), possession of a more constricted region between the body and the tail, much smaller pectoral fins, and pelvic fins which are never drawn forward far enough to lie beneath the pectorals.

Schaefferichthys (Dalquest 1966) is a poorly known form from the Permian of Texas. It is generally platysomid in form and has a finely vermiform scale-ornamentation pattern aligned in parallel vertical rows as in *Platysomus.* It may be possible that this species is a primitive bobasatraniform, but the scale-ornamentation pattern debars it from any close relationship with *Tanypterichthys.*

Paraeurynotus (Obruchev 1962) is poorly known, but the scale proportions (only two times higher than wide) and ornamentation (nearly smooth) are markedly different from those of *Tanypterichthys.* Additionally, it is remote in time from our form (Early Permian).

Eurynotoides (Berg 1940a) has very nearly a normal fish shape and scale structure, and it is also remote in time (Late Permian) from *Tanypterichthys*; obviously it is not closely related to our specimen.

Caruichthys (Broom 1913, Lehman 1966) of the Early Triassic is remote in time from *Tanyperichthys,* a smaller form (about 20 cm long), and covered with scales that are ornamented by irregular prominent transverse ridges.

Globulodus (Munster 1842, King 1850, Young 1866, Traquair 1879, Woodward 1891, Brough 1934, Westoll 1941, Berg et al. 1964, Schaumberg 1980) shows some obvious similarities to *Tanypterichthys.* The scales are coarsely striated and their pin and socket arrangement is located along the edge of the scale, the size is large (a maximum of 40 cm), and the constriction between the body and the tail is persistently thick for a deep-bodied paleonisciform fish. Yet the anal fin is not nearly so elongated and the adjacent postero-ventral flank scale columns are not turned downward and forward as they are in *Tanypterichthys.* In these characteristics, *Globulodus* is persistently the more primitive form, even though it is much younger in age (Late Permian). This temporal progression in specialization from derived to primitive seems to debar any direct lineage between these two forms. Probably the similarity in tail structure is a shared primitive trait retained in both forms and should not be considered to be of phylogenetic signficance; the position of the pin and socket arrangement also is shared by many other forms in this family. Large size (40 cm) and a relatively thick tail constriction also are characteristics of *Adroichthys,* which otherwise is not especially close in its morphology to either *Globulodus* or *Tanypterichthys.*

Some other forms formerly placed among the deep-bodied paleonisciforms ("*Eurynotus*" *uspallatensis* (Rusconi 1946a), "*Platysomus*" *pehuenchensis* (Rusconi 1946b) and "*Platysomus*" *cajonensis* (Rusconi 1948), from the Triassic and Jurassic of Argentina) probably do not belong there. What little that is known of them suggests that their scales are not so elongate as those of *Tanypterichthys* and not similarly ornamented. The unnamed platysomid from the Triassic of Australia mentioned by Banks (1978) is, if correctly identified, probably the youngest representative of this family.

Two other recognized families, also deep bodied and frequently considered to be paleonisciforms, are the Dorypteridae and the Dorsolepidae. The monogeneric Dorypteridae (Westoll 1941, Schaumberg 1980) is known only from Late Permian marine beds. This family is characterized by a very unusual body shape and the loss of nearly all trace of a scale coat, characteristics that are not remotely similar to those found in our fish. The monogeneric Dorsolepidae, known only from the Early Triassic, is represented only by the form *Dorsolepis* (Jorg 1969a, b; Gall et al. 1974). It has been associated with the platysomids, but only its narrow and deep body form strongly suggests any affinity. Its scales are greatly reduced and it is very small (5 cm), so it has no close similarity to *Tanypterichthys.*

The marine-going Bobasatraniformes, which includes *Bobasatrania canadensis* (Schaeffer and Mangus 1976), *B. groenlandica* (Stensio 1932, Nielsen 1952, Lehman 1957), *B. mahavavica* (White 1932, Lehman 1957), *B. nathorsti* (Stensio 1921), *Ebenaqua ritchiei* (Campbell and Phuoc 1983), *Ecrinesomus dixoni* (Woodward 1910, Lehman 1957), *Lambeichthys canadensis* (Lambe 1914, Russell 1951, Lehman 1966), "*Platysomus*" *brewsteri* (Warren 1936, Lehman 1966), *Tompoichthys abramovi* (Berg et al. 1964, Lehman 1966), and *Sinoplatysomus meishanensis* (Wei 1980), are all forms that are grossly similar in appearance to *Tanypterichthys.* However, their scale ornamentation, where described, is finely vermiform in vertically parallel ridges, and the constriction between the body and tail is extreme, being only about four scale rows thick. *Sinoplatysomus* and *Ebenaqua* are from the Late Permian, and the other members of this family are from the Early Triassic. The pectoral fin of *Tanypterichthys* is similar to that of *Bobasatrania*, but otherwise shows no special similarity to any member of this family except in its relatively large size. Moreover, the preserved portion of the cheek region in *Tanypterichthys* shows that it contains numerous branchiostegal rays. In contrast, bobasatraniforms have the cheek region highly modified from the primitive paleonisciform condition and the branchiostegal rays have been largely or wholly removed from lateral view (Schaeffer and Mangus 1976). Its gross similarities to the bobasatraniform fishes are considered here to be the result of convergence rather than any intimate relationship.

Thus *Tanypterichthys*, although it falls within the definition of the Paleonisciformes and bears some resemblance to the Bobasatraniformes, cannot be shown to have a clear and close affinity to any other genus so far described within either of those two orders. *Tanypterichthys* therefore warrants recognition as a new and separate genus that can be defined as follows:

Order Paleonisciformes
Tanypterichthys, new genus

Diagnosis.—*Tanypterichthys* differs from all other paleonisciforms by the following combination of characters. Scales vertically elongate (as much as 4 times longer than wide), ornamented with a complex pattern consisting of globular papillae and randomly oriented, short, thick ridges reminiscent of the scale ornamentation in *Wardichthys*; scales arrayed in about 50 columns (from behind the head to the constricted portion of the tail) and in rows of 15 (near the tail) to no more than 26 (near the middle of the body). Posterior skull elements ornamented with a fine, vermiform, vertically aligned pattern of parallel ridges very different from the body scale pattern. Pectoral fins greatly elongated and expanded as in *Eurynotus*, *Caruichthys*, and *Bobasatrania*, more than half as long as the body. Pelvic fins long, thin, subcylindrical, and inserting far forward on the body beneath the distal part of the pectoral fins, length about one-third that of the body. Anal fin greatly elongated, bordering along the entire length of the back half of the body and turning the adjacent postero-ventral scale columns forward in a manner similar to that seen in *Platysomus striatus*. Constriction between the body and the tail pronounced, but less so than in other deep-bodied members of this order except *Adroichthys* and *Globulodus*. Size very large, as much as 0.5 m.

Type species.—*Tanypterichthys pridensis*, new species.

Tanypterichthys pridensis, new species
Figs. 3–11

Type specimen.—USNM 391949, a large calcareous concretion containing the bulk of the body, the back edge of the skull, pectoral fins, pelvic fins, and the anal fin.

Type locality.—At the northwest end of the Camp Creek Interchange along the West Virginia Turnpike, Mercer County, West Virginia, at latitude 37°29′25″N and longitude 81°06′25″W.

Horizon.—About 6 inches above a rubble zone at the base of the Pride Shale Member of the Bluestone Formation (Upper Mississippian Series).

Collector.—John F. Windolph, Jr., 20 Nov 1982.

Diagnosis.—As for the genus.

Etymology.—The pectoral fin is unusual in appearance, being very large and elongate, and it is this striking characteristic to which the generic name alludes (*tany-* = stretched out, *pteryx* = fin or wing, *ichthys* = fish). The specific name reflects the occurrence of the specimen in the Pride Shale Member of the Bluestone Formation.

Discussion.—Electron photomicrographs were made of a fragment of one bony scale

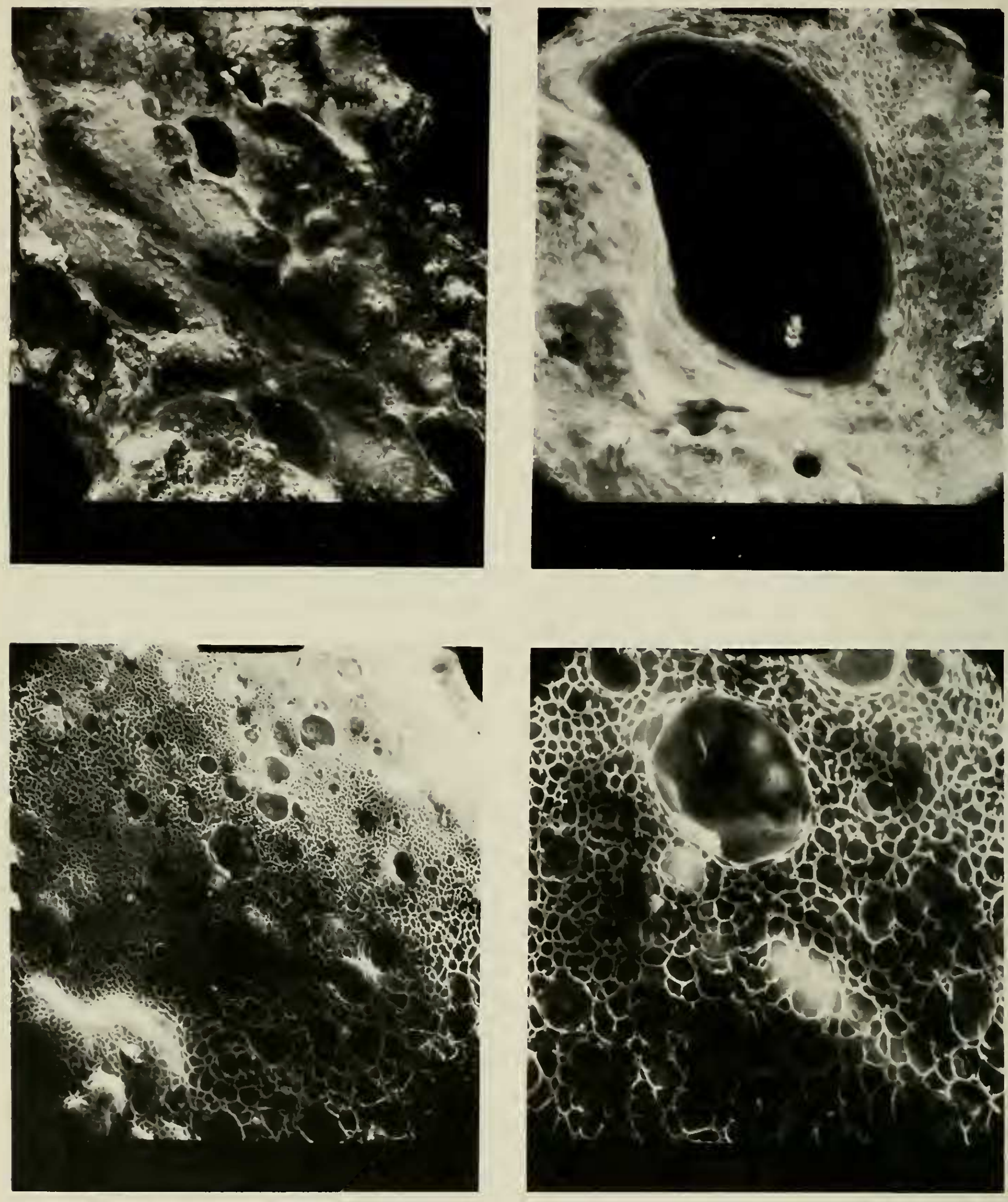

Fig. 9. Electron photomicrographs of details of a single scale from the postero-medial region of the left flank of the type specimen of *Tanypterichthys pridensis* (USNM 391949). Upper left, scale surface showing ridges (running from upper left to lower right) and nutrient foramina (top center); upper right, detail of the nutrient foramina in the top center of the upper left picture; lower left, more detailed view showing the cellular structure of the scale; lower right, more detailed view showing the central region of the lower left picture. Photos by Richard Larson (U.S. Geological Survey, Reston).

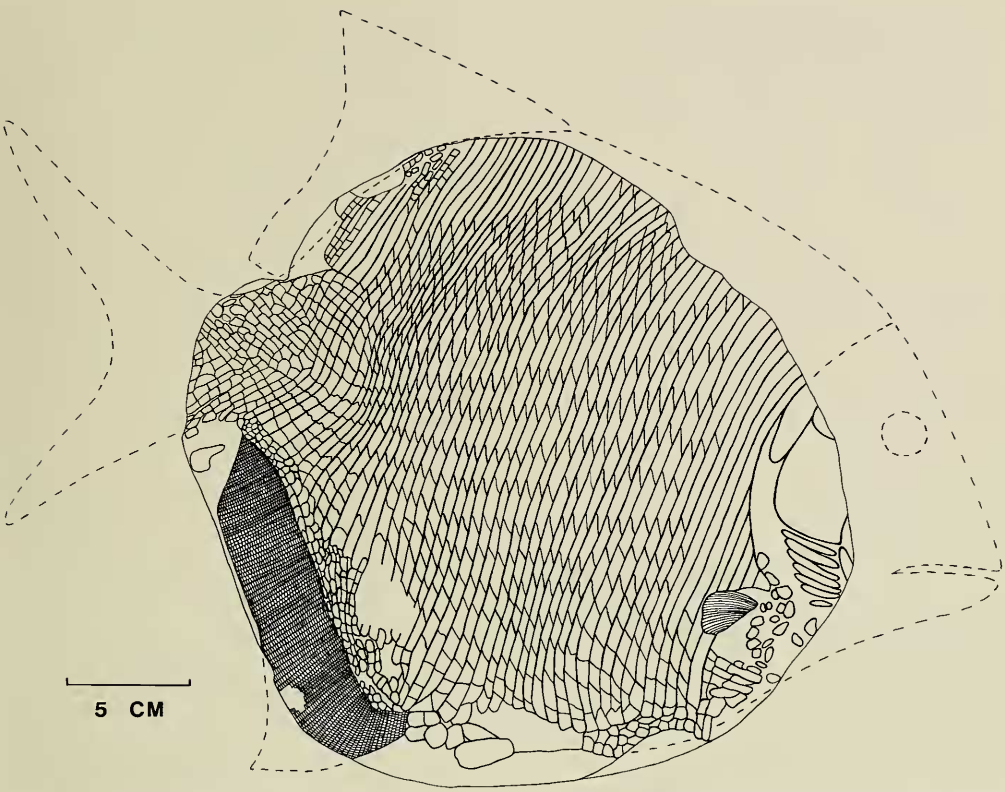

Fig. 10. Sketch showing the scale pattern and anal fin shape as seen from the internal view of the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949) before acid preparation.

by Richard Larson (U.S. Geological Survey, Reston), and details of the well preserved bone structure and nutrient channels are shown at four different magnifications (Fig. 9). SEM spectral analysis of the fragment showed calcium and phosphorus as major elements, and silicon, aluminum, iron, and sulfur as minor elements.

No trace of the appendicular skeleton was observed. Possibly the concretion split through the scales on one side of the body, so that the remains of a bony skeleton were not revealed. If so, there is no trace of the shapes of such bones revealed by warpage of the visible internal scale surfaces. Therefore, it seems more likely that the concretion split through the middle of the fish, and the appendicular skeleton had left no trace of its former presence. The proportions of the bones at the back of the skull are normal for a platysomid and require no special discussion, though their parallel vermiform pattern (reminiscent of *Platysomus*) is strikingly different from the scale-ornament pattern. Parts of the front, top, and back of the body are missing, but general proportions can be estimated from the available remains. Deep-bodied paleonisciform fishes are known to have 15 (*Paramesolepis tuberculata*) to 26 (*Eurynotus, Soetendalichthys*) rows of scales present in each vertical column near the deepest part of the body. Because about 22 scale rows are preserved in the type specimen of *Tanypterichthys,* the top of the body almost certainly did not extend any higher than 4 more short scale-

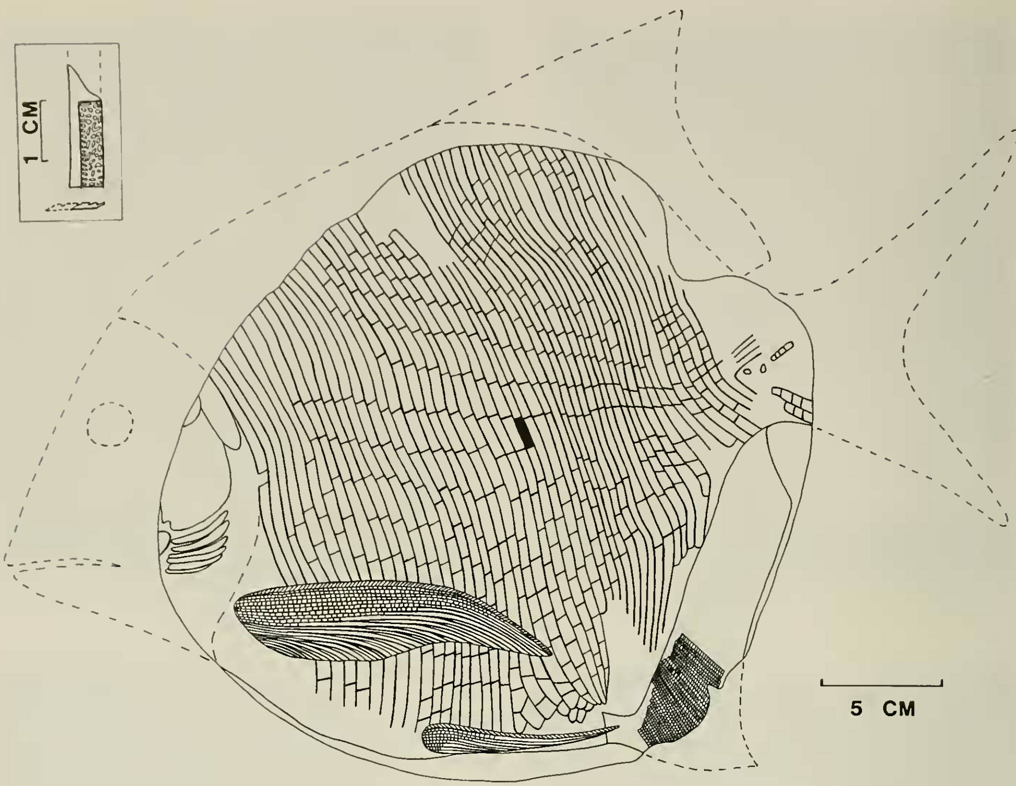

Fig. 11. Sketch showing scale pattern, pectoral fin, and pelvic fin as seen from the external view of the left side of the type specimen of *Tanypterichthys pridensis* (USNM 391949) after acid preparation. Shape of the anal fin was derived from Fig. 10; the general body form is assumed to be typically platysomid. Inset shows the details of the construction and ornamentation of a single flank scale (shaded black on the fish body) and its relationships to surrounding scales.

heights above the level of the preserved upper margin. Likewise, when a large anal fin is found in other fishes in this family, it is matched by an equally large or larger dorsal fin (for example, *Platysomus superbus* or *Ebenaqua ritchiei*). The gross shape of the skull and the shape of the tail are not greatly variable in known members of this group; therefore, the rough outlines of the body reasonably can be surmised in addition to the observable detailed patterns of the preserved parts (Figs. 10, 11).

Functional Anatomy

The outline of the flank scales is markedly different in internal and external aspect (see Figs. 3, 4). This is because the scales are hinged along their dorsal and ventral borders in such a manner that the internal anterior dorsal border forms a pinlike slip. This slip inserts beneath the internal anterior ventral border of the next scale above it where it is embayed from the internal side to form a socket (see Fig. 11). This general kind of structure is probably normal among deep-bodied paleonisciform fish, though in *Eurynotus* (Traquair 1879) and *Soetendalichthys* (Gardiner 1969) the pins and sockets are in the center of the scales, and in *Adroichthys* (Gardiner 1969) they are slightly off-center. In *Globulodus* (Agassiz 1833–43, King 1850), *Platysomus* (Traquair 1879), *Cheirodus* (Traquair 1879), and *Tanypter-*

ichthys, the pin is formed by an upper corner of the scale. The function of this arrangement seems to have been to strenghten the ganoid scale coating and thus to form a chain-mail effect through a combination of antero-posterior overlapping and vertical interlocking of the scales. Such an interlocking arrangement would be mobile only around a vertical axis, and the body movement of these fishes would be restricted to lateral flexure. Such restriction in body motion is probably correlated with the very deep body form of the animal. The fact that the body armor did not evolve to a greater rigidity suggests that these fishes did need to preserve their ability to move in a laterally undulatory, normal piscine fashion.

The dorsal fin of *Tanypterichthys* is unknown, but in better known members of the family that also have expanded anal fins (for example, *Platysomus superbus* (Moy-Thomas and Dyne 1938) and *Ebenaqua ritchiei* (Campbell and Phuoc 1983)) great expansion and elongation of the anal fin is matched by an equal or greater development of the dorsal fin. Such well developed sets of anal and dorsal fins in modern fishes usually function to propel their bearer at slow speeds by undulations of these two fins without marked undulation of the body as a whole. The well-developed anal fin, present in *Tanypterichthys* and in many of the other deep-bodied paleonisciforms and bobasatraniforms, suggests that a similar mode of propulsion probably was employed.

The pectoral and pelvic fins are strongly modified from the generalized actinopterygian condition, which suggests that they were specialized in function. The large pectorals were braced along their dorsal border by an enlarged row of scales (see Fig. 5), which probably afforded them exceptional strength for an actinopterygian. These large fins could have poled the fish forward while it cruised near the bottom or functioned as oars for maneuvering the body fore, aft, and in tight circles. The pelvic fins are long but very thin. They could have functioned in murky water as feelers to keep the fish slightly above the bottom or as claspers during mating as similarly shaped pelvic fins do in many modern actinopterygians.

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